Claims

1. A method for the qualitative evaluation of a material (19) with at least one identifying characteristic (79), wherein a color image (79) is recorded by means of an electronic image sensor (02) of at least the identifying characteristic (79), wherein at least one first electrical signal (09) which is correlated with the color image is made directly or indirectly available by the image sensor (02), wherein an evaluating device (03), which is connected with the image sensor (02), evaluates the first electrical signal (09), wherein a second electrical signal is obtained from at least one reference image and is stored in a data memory (14), wherein the second electrical signal has a reference variable (16, 17, 18) of at least two different properties of the reference image for the first electrical signal (09), wherein the first signal (09) is compared with at least two of the reference variables (16, 17, 18) contained in the second electrical signal, wherein during the comparison at least the color image of the identifying characteristic (79) is checked for a deviation from the reference image, and the identifying characteristic (79) is checked regarding its association with a defined class of identifying characteristics (79), or a defined geometric contour or a relative arrangement in respect to at least one further identifying characteristic (79) of the material (19), characterized in that the checks take place during a running printing process of a printing press, or a running work process of a machine processing the material (19).

2. A method for the qualitative evaluation of a material (19) with at least one identifying characteristic (79), wherein a color image is recorded by means of an electronic image sensor (02) of at least the identifying characteristic (79), wherein at least one first electrical signal (09) which is correlated with the color image is made directly or indirectly available by the image sensor (02), wherein an evaluating device (03), which is connected with the image sensor (02), evaluates the first electrical signal (09), wherein a second electrical signal is obtained from at least one reference image and is stored in a data memory (14), wherein the second electrical signal has a reference variable (16, 17, 18) of at least two different properties of the reference image for the first electrical signal (09), wherein the first signal (09) is compared with at least two of the reference variables (16, 17, 18) contained in the second electrical signal, wherein during the comparison at least the color image of the identifying characteristic (79) is checked for a deviation from the reference image, and the identifying characteristic (79) is checked regarding its association with a defined class of identifying characteristics (79), or a defined geometric contour or a relative arrangement in respect to at least one further identifying characteristic (79) of the material (19), characterized in that at least two of the checks take place independently of each other in parallel extending check processes.

3. A method for the qualitative evaluation of a material (19) with at least one identifying characteristic

(79), wherein a color image is recorded by means of an electronic image sensor (02) of at least the identifying characteristic (79), wherein at least one first electrical signal (09) which is correlated with the color image is made directly or indirectly available by the image sensor (02), wherein an evaluating device (03), which is connected with the image sensor (02), evaluates the first electrical signal (09), wherein a second electrical signal is obtained from at least one reference image and is stored in a data memory (14), wherein the second electrical signal has a reference variable (16, 17, 18) of at least two different properties of the reference image for the first electrical signal (09), wherein the first signal (09) is compared with at least two of the reference variables (16, 17, 18) contained in the second electrical signal, wherein during the comparison at least the color image of the identifying characteristic (79) is checked for a deviation from the reference image, and the identifying characteristic (79) is checked regarding its association with a defined class of identifying characteristics (79), or a defined geometric contour or a relative arrangement in respect to at least one further identifying characteristic (79) of the material (19), characterized in that the checks of the color image take place on the basis of the reference image stored in the data memory (14), which is part of the evaluating device (03), in the course of a learning mode (48) of the evaluating device (03), by means of the evaluating device (03) after it has changed from its learning mode (48) into a working mode (49).

4. The method in accordance with claim 2 or 3, characterized in that the checks take place during a running printing process of a printing press, or a running work process of a machine processing the material (19).

5. The method in accordance with claim 1 or 3, characterized in that at least two of the checks take place independently of each other in parallel extending check processes.

6. The method in accordance with claim 1 or 2, characterized in that the checks of the color image take place on the basis of the reference image stored in the data memory (14), which is part of the evaluating device (03), in the course of a learning mode (48) of the evaluating device (03), by means of the evaluating device (03) after it has changed from its learning mode (48) into a working mode (49).

7. The method in accordance with claim 3 or 6, characterized in that a single reference image or several reference images are recorded during the learning mode (48).

8. The method in accordance with claim 1 or 4, characterized in that the material (19) is imprinted during the running print process.

9. The method in accordance with claim 1, 2 or 3, characterized in that the evaluation of the material (19) is performed for the control of its quality.

10. The method in accordance with claim 1, 2 or 3, characterized in that the material (19) is a bill (19) or a stamp (19).

11. The method in accordance with claim 1, 2 or 3, characterized in that the material (19) is designed as a printed sheet (19) and is moved past the image sensor (02) at a speed of up to 18,000 printed sheets.

12. The method in accordance with claim 1, 2 or 3, characterized in that the material (19) is embodied as a web (19) of material and is moved past the image sensor (02) at a speed of up to 15 m/s.

13. The method in accordance with claim 1, 2 or 3, characterized in that the position of the identifying characteristic (79) varies within an expected range (78) defined by tolerance limits.

14. The method in accordance with claim 1, 2 or 3, characterized in that the image sensor (02) has several light-sensitive pixels.

15. The method in accordance with claim 14, characterized in that a first electrical signal (09) is made available for every pixel.

16. The method in accordance with claim 1, 2 or 3, characterized in that the first electrical signal (09) has been divided onto several signal channels (R, G, B).

17. The method in accordance with claim 16, characterized in that the first electrical signal (09) is an RGB signal, so that every signal channel (R, G, B) makes available a portion of the first signal (09) corresponding to one of the three basic colors red, green and blue.

18. The method in accordance with claim 16, characterized in that the spectral sensitivity in each signal channel (R, G, B) is set to a defined spectral sensitivity of the human eye.

19. The method in accordance with claim 1, 2 or 3, characterized in that in regard to hue, fullness and brightness the first signal (09) is matched to the color perception of the human eye.

20. The method in accordance with claim 16, characterized in that the check of the color image for a deviation of the color image from the reference image takes place in that the portion of the first signal (09) which is a part of the color image made available in the first signal channel (R) is linked by means of a first calculation prescription (36) with the portion made available in the second signal channel (G), by means of which an output signal (43) of a first compensation color channel (38) is generated, that the portion of the first signal (09) which is a part of the color image made available in the third channel (B) is linked by means of a second calculation prescription (37) with the portion in the first and second signal channels (R, G), by means of which an output signal (44) of a second

compensation color channel (39) is generated, and that the output signals (43, 44) of the compensation color channels (38, 39) are classified by means of a comparison with reference variables.

21. The method in accordance with claim 20, characterized in that the output signal (43, 44) of each compensation color signal (38, 39) is stored in the data memory (14).

22. The method in accordance with claim 20, characterized in that the first calculation prescription (36) provides a weighted difference formation of the portion of the first electrical signal (09) made available in the second signal channel (G) from the corresponding portion in the first signal channel (R), and/or the second calculation prescription (37) provides a weighted difference formation of the weighted sum of the portions in the first and second signal channel (R, G) from the corresponding portion in the third signal channel (B).

23. The method in accordance with claim 20, characterized in that at least one of the portions of the first electrical signal (09) made available in the signal channels (R, G, B) is subjected to a transformation (41) by means of a calculation prescription (36, 37) prior to and/or following their linkage.

24. The method in accordance with claim 23, characterized in that a non-linear transformation is used.

25. The method in accordance with claim 20, characterized in that each one of the portions of the first electrical signal (09) which is taken into consideration during a linkage is weighted with a coefficient (42) prior to and/or after the transformation (41).

26. The method in accordance with claim 20, characterized in that the output signal (43, 44) of at least one compensation color channel (38, 39) is filtered by means of a low pass filter (47).

27. The method in accordance with claim 26, characterized in that the low pass filter (47) is designed as a Gauss low pass filter.

28. The method in accordance with claim 20, characterized in that in the learning mode (48) the output signals (43, 44) of the two compensation color channels (38, 39) produced by at least one reference image are stored as reference variables in the data memory (14), and wherein in the working mode (49) the output signals (43, 44) from the two compensation color channels (38, 39) generated by the identifying characteristic (79) to be checked are compared with the reference variables stored in the data memory (14).

29. The method in accordance with claim 20, characterized in that the comparison of the output signals (43, 44) of the two compensation color channels (38, 39) generated by the identifying characteristic (79) to be checked with the reference variables stored in the data

memory (14) takes place for each pixel of the image sensor (02).

30. The method in accordance with claim 29, characterized in that the reference variables stored for each pixel in the data memory (14) are generated by storing the output signals (43, 44) from several reference images, by means of which a tolerance window is defined for the reference variables.

31. The method in accordance with claim 20, characterized in that the classification (54) of the output signals (43, 44) of the compensation color channels (38, 39) is performed by means of a classification system.

32. The method in accordance with claim 31, characterized in that linear and/or non-linear classification systems, threshold value classification devices, Euclidic distance classification devices, Bayes classification devices, fuzzy classification devices or artificial neuronal networks are employed.

33. The method in accordance with claim 1, 2 or 3, characterized in that the check of the identifying characteristic (79) regarding its association with a defined class of identifying characteristics (79) takes place in that the first electrical signal (09) made available by the image sensor (02) is converted by means of at least one calculation prescription to a translation-invariable signal with at least one characteristics value (62), that the characteristics

value (62) is weighted with at least one fuzzy association function (67), that a higher order fuzzy association function (71) is generated by the linkage of all association functions (67) by means of a calculation prescription consisting of at least one rule, that a sympathetic value (73) is determined from the higher order fuzzy association function (71), that the sympathetic value (73) is compared with a threshold value (76), and that as a function of the result of this comparison a decision is made regarding an association of the identifying characteristic (79) with a defined class of identifying characteristics (79).

34. The method in accordance with claim 33, characterized in that a grid of several image windows (56) is placed over the color image, wherein each image window (56) consists of several pixels.

35. The method in accordance with claim 34, characterized in that the color image is divided into M x N image windows (56), each with m x n pixels, wherein M, N, m, n = 1.

36. The method in accordance with claim 33, characterized in that the association function (57) has a functional connection with the value range of the characteristics value (62).

37. The method in accordance with claim 36, characterized in that the association function (57) has at least one parameter, and this parameter is determined.

38. The method in accordance with claim 33, characterized in that the calculation prescription for converting the first electrical signal (09) from the image sensor (02) into a translation-invariable characteristics value (62) is a two-dimensional mathematical spectral transformation method (58).

39. The method in accordance with claim 38, characterized in that the calculation prescription is a two-dimensional Fourier or Walsh or Hadamard or circular transformation.

40. The method in accordance with claim 38, characterized in that the characteristics value (62) is represented by the amount of a spectral coefficient (59).

41. The method in accordance with claim 34, characterized in that two-dimensional spectra from the first electrical signal (09) made available by the image sensor (02) for each pixel are determined for each image window (56).

42. The method in accordance with claim 41, characterized in that spectral amplitude values (62) are calculated from the two-dimensional spectra and are linked to form a single sympathetic value (73) per image window (56).

43. The method in accordance with claim 33, characterized in that the association functions (67) are unimodal functions.

44. The method in accordance with claim 33, characterized in that the higher order association function (71) is a multi-modal function.

45. The method in accordance with claim 33, characterized in that the association functions (67) and/or the higher order association function (71) is (are) a potential function(s).

46. The method in accordance with claim 33, characterized in that in the learning mode (48) at least one parameter is conformed or at least one threshold value (76) is determined, and wherein in the working mode (49) the first electrical signal (49) made available by the image sensor (02) is evaluated on the basis of the results from the learning mode (48).

47. The method in accordance with claim 33, characterized in that the calculation prescription by means of which the association functions (67) are compared with each other is a conjunctive association function (69) within the meaning of IF...THEN linkage.

48. The method in accordance with claim 33, characterized in that the generation of the higher order fuzzy association function (71) takes place by processing the partial steps of premise evaluation, activation and aggregation, wherein in the course of the premise evaluation a sympathetic value (73) is determined for each IF portion of a calculation prescription, and wherein in the course of the

activation an association function (67) is determined for each IF...THEN calculation prescription, and wherein in the course of aggregation the higher order association function (71) is generated by overlapping all association functions (67) created during activation.

49. The method in accordance with claim 33, characterized in that the sympathetic value (73) is determined in accordance with a focus and/or maximum method.

50. The method in accordance with claim 1, 2 or 3, characterized in that the check of the identifying characteristics (79) for a defined geometric contour or for a relative arrangement in respect to at least one further identifying characteristic (79) of the material (19) takes place in that at least one background reference variable and at least one mask reference variable are stored in the data memory (14), wherein the background reference variable represents at least one property of the material (19) to be evaluated in at least one portion of an expected range (78) surrounding the identifying characteristic (79), and wherein the mask reference variable represents the geometric contour of the identifying characteristic (79) or the relative arrangement in respect to each other of several identifying characteristics (79), that in the course of checking the material (19) a differential value is formed at least for the expected range (78) from the electrical signal (09) made available by the image sensor (02) and the background reference variable, that the actual position of the identifying characteristic (79) is derived from a comparison

of the differential value with the mask reference variable, and that the area of the material (19) to be evaluated, which results from the actual position of the identifying characteristic (79), is blanked out for the qualitative evaluation of the material (19).

51. The method in accordance with claim 50, characterized in that the background reference variable represents the gray value of the expected range (78) surrounding the identifying characteristic (79).

52. The method in accordance with claim 50, characterized in that a binary formation threshold is stored in the data memory (14), wherein all first electrical signals (09) made available by the image sensor (02), whose value falls below the binary formation threshold, are filtered out of the differential value.

53. The method in accordance with claim 50, characterized in that in the course of the determination of the position of the identifying characteristic (79) the mask reference variable is conformed until a maximum agreement between the mask reference variable and the differential value results.

54. The method in accordance with claim 50, characterized in that in the course of the determination of the position of the identifying characteristic (79) a comparison of the foci of the mask reference variables with the foci of the differential value takes place.

55. The method in accordance with claim 54, characterized in that those position values are assumed to be the actual position of the identifying characteristic (79), wherein a minimal deviation results during the comparison of the foci of the mask reference variables with the foci of the differential value.

56. The method in accordance with claim 50, characterized in that the identifying characteristic (79) is embodied in the form of strips or has strip-shaped sections.

57. The method in accordance with claim 50, characterized in that the identifying characteristic (79) is designed as a security characteristic of a bill (19) or a stamp (19).

58. The method in accordance with claim 50, characterized in that the identifying characteristic (79) is designed as a window thread (79), a window thread perforation (79, 91), a hologram or a kinegram.

59. The method in accordance with claim 50, characterized in that, for determining the background reference variable, material (19) without an identifying characteristic (79) is used in the learning mode (48), wherein the background reference variable is derived from at least one property of the material (79) to be evaluated in the expected range (78).

60. The method in accordance with claim 50, characterized in that, for determining the background reference variable, material (19) with an identifying characteristic (79) is used in the learning mode (48), wherein in case of an identifying characteristic (79) which appears bright in comparison with the expected range (78), the background reference variable is derived as a threshold value from the values of the darkest image points of the identifying characteristic (79), and wherein in case of an identifying characteristic (79) which appears dark in comparison with the expected range (78), the background reference variable is derived as a threshold value from the values of the brightest image points of the identifying characteristic (79).

61. The method in accordance with claim 50, characterized in that different background reference variables are determined for different areas of the material (19).

62. The method in accordance with claim 50, characterized in that the mask reference variable and the differential value are each projected onto at least one projection line (96, 97), wherein the actual position of the identifying characteristic (79) in the longitudinal direction of the projection lines (96, 97) is derived from a comparison of the projection data of the mask reference values and the differential value.

63. The method in accordance with claim 50, characterized in that the check of the identifying characteristic (79) takes place by means of suitable mathematical operations of digitized input data.

64. The method in accordance with claim 16, characterized in that the first electrical signal (09) is a signal vector (22), whose coefficients (R, G, B) represent the portions of the first electrical signal (09) made available by the image sensor (02) in different signal channels (R, G, B), that the coefficients (R, G, B) are multiplied by a correction matrix (28), that the corrected signal vector (29) obtained in the course of this is supplied to a color monitor (04), and the color image is represented at the color monitor (04) on the basis of the corrected signal vector (29) for the qualitative evaluation of the latter.

65. The method in accordance with claim 64, characterized in that the correction matrix (28) is quadratic.

66. The method in accordance with claim 64, characterized in that the coefficients (K_4 to K_{12}) of the correction matrix (28) are determined in an iterative approximation algorithm, in which a reference color chart has been preset, in which different reference colors are represented in several color fields, wherein for each color field of the reference color chart a vector with reference values has been preset, wherein a color image from the

reference color chart is recorded by the image sensor (02), wherein a signal vector (22) is determined for each color field wherein, in a first iteration step, the signal vectors (22) for all color fields are multiplied by the correction matrix (28), and wherein the coefficients (K_4 to K_{12}) of the correction matrix (28) are changed in each subsequent iteration step in such a way that the corrected signal vectors (29) are iteratively brought close to the vectors with the preset reference variables.

67. The method in accordance with claim 66, characterized in that the approach of the corrected signal vectors (29) to the vectors with the preset reference variables are evaluated for each iteration step in that the differential value between the corrected signal vector (29) and the vector with the preset reference variables is determined for each color field of the reference color chart and the sum of all differential values is added up, wherein the change of the coefficients (K_4 to K_{12}) of the correction matrix (28) in the actual iteration step is assumed for the subsequent iteration step only if the sum of all differential values in the actual iteration step has become smaller in comparison with the sum of all differential values in the previous iteration step.

68. The method in accordance with claim 64, characterized in that, for matching the color balance, the brightness and the contrast, in a further correction step the signal vectors (22) are changed, in addition to the correction with the correction matrix (28), in such a way

that the coefficients (R, G, B) of each signal vector (22) are multiplied by signal channel-dependent correction factors (K_1, K_2, K_3) and a correction vector (24) is added to each signal vector (22).

69. The method in accordance with claim 68, characterized in that the coefficients (a_1, a_2, a_3) of the correction vector (24) and the signal channel-dependent correction factors (K_1, K_2, K_3) are determined in that a reference color chart is preset in which different reference colors are represented in several color fields, wherein a vector with reference variables has been preset for each color field of the reference color chart, wherein a color image from the reference color chart is recorded by the image sensor (02), wherein a signal vector (22) is determined for each color field, wherein the correction vector (24) and the correction factors (K_1, K_2, K_3) are selected in such a way, that the corrected signal vectors (26) for the two color fields with the reference gray values black and white, which are obtained by appropriate addition with the correction vector (24) and by means of a multiplication with the signal channel-dependent correction factors (K_1, K_2, K_3), agree with the preset reference variables for these two color fields.

70. The method in accordance with claim 68 or 69, characterized in that the correction step for matching the color balance, the brightness and the contrast is performed prior to the multiplication with the correction matrix (28).

71. The method in accordance with claim 64, characterized in that the image sensor (02) has a plurality of pixels arranged flat or in a linear shape, wherein each pixel provides at least one signal vector (22).

72. The method in accordance with claim 71, characterized in that in addition to the correction with the correction matrix (28), the signal vector (22) is changed in a further correction step for conforming the intensity values in such a way, that the coefficients (R, G, B) of the corrected signal vectors (26, 29) or uncorrected signal vectors (22) determined for each pixel are each multiplied with signal channel-dependent correction factors (K_{13}, K_{14}, K_{15}, K_{16}, K_{17}, K_{18}), which have been specifically preset for each pixel.

73. The method in accordance with claim 72, characterized in that the pixel-specific signal channel-dependent correction factors (K_{13}, K_{14}, K_{15}, K_{16}, K_{17}, K_{18}) are determined in that the observation area (21) of the image sensor (02) has been lined with a homogeneous colored material, in particular a homogeneous white material, that a color image is recorded by means of the image sensor (02) and that in this way a signal vector (22) is determined for each pixel, that the particular signal vector (22) is defined, which represents the brightest location in the observation area (21), and that the pixel-specific signal channel-dependent correction factors (K_{13}, K_{14}, K_{15}, K_{16}, K_{17}, K_{18}) are determined for each pixel in such a way that the result

of the multiplication of these correction factors (K_{13}, K_{14}, K_{15}, K_{16}, K_{17}, K_{18}) with the coefficients (R, G, B) of the respective corresponding signal vectors (22) agrees with the coefficients (R, G, B) of the signal vector (22) at the brightest location in the observation area.

74. The method in accordance with claim 73, characterized in that during the determination of the pixel-specific signal channel-dependent correction factors (K_{13}, K_{14}, K_{15}, K_{16}, K_{17}, K_{18}) the illumination in the observation area (21) corresponds to the illumination of the image sensor (02) during the qualitative evaluation of the material (19).

75. The method in accordance with claim 72, characterized in that the correction step for matching the intensity values is performed after the multiplication with the correction matrix (28).

76. The method in accordance with claim 65, characterized in that, prior to being transmitted to the color monitor (04), the coefficients (R, G, B) used as the basis for the corrected signal vectors (32) are each raised to a higher power by a factor (gamma).

77. The method in accordance with claim 76, characterized in that the factor (gamma) is selected to have a value between 0.3 and 0.5.

78. The method in accordance with claim 76, characterized in that the factor (gamma) is selected to be approximately 0.45.

79. The method in accordance with claim 64, characterized in that, in addition to the correction by means of the correction matrix (28), for matching the illumination conditions the signal vectors (22) are changed in a further correction step in such a way that the coefficients of the corrected signal vectors correspond to the result which is obtained when the observation area is illuminated with normal light.

80. The method in accordance with claim 64, characterized in that the reference color chart is designed in the manner of an IT8 chart with a total of 288 color fields.

81. The method in accordance with claim 64, characterized in that the vectors with the reference variables are specified for the signal channels by conversion of the CIELAB color values, which are known for the color fields of the reference color chart, into appropriate coefficients for the signal channels.